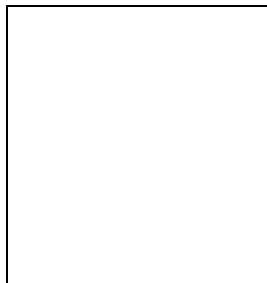


MEASUREMENT OF V_{ub} AT BELLE

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Results on two inclusive V_{ub} measurements at Belle are presented. We also present a new measurement of the branching fraction for $D_s \rightarrow \phi\pi$. A data sample of 78.1 fb^{-1} accumulated using the Belle detector at the KEKB asymmetric e^+e^- collider operating at the $\Upsilon(4S)$ resonance is used. All results are preliminary.

1 Introduction

The large sample of $\Upsilon(4S)$ decay events produced by KEK-B, and studied with the Belle detector has inspired the use of new methods to measure the Cabibbo-Kobayashi-Maskawa matrix element, V_{ub} .

The Belle detector is described in detail elsewhere.¹ It consists of a silicon vertex detector, a central drift chamber (CDC), aerogel Cerenkov counters (ACC), time-of-flight scintillation counters (TOF) and an electromagnetic calorimeter made of CsI(Tl) crystals enclosed in alternating layers of resistive plate chambers and iron for K_L/μ detection and to return the flux of the 1.5 T magnetic field.

The measurement of $|V_{ub}|$ via the study of charmless semileptonic B decays has proved difficult due to overwhelming background from charm semileptonic B decays. Traditional measurements are derived from an examination of the charged lepton yields at the end point of the momentum spectrum. The precision of eventual $|V_{ub}|$ extractions are limited since at best end point measurements access roughly 10% of the total $B \rightarrow X_u l \nu$ phase space. Recent work has shown methods which can measure the hadronic recoil mass, M_{X_u} , and leptonic mass, $q^2 \equiv (p_l + p_\nu)^2$, offer more precise $|V_{ub}|$ measurements².

A model dependent $|V_{ub}|$ extraction is possible in measurements in $B^0 \rightarrow D_s^+ \pi^-$ decays³. Both BaBar and Belle collaborations have measured the branching fraction for $B^0 \rightarrow D_s^+ \pi^-$ decay^{8,9}. The largest contribution to the systematic error is the uncertainty in the rate of $D_s \rightarrow \phi\pi$. A more precise measurement of the rate will aid any eventual $|V_{ub}|$ extraction.

2 Inclusive $|V_{ub}|$ measurements

2.1 Pseudo full reconstruction of the $\Upsilon(4S)$ via two semileptonic B decays

$\Upsilon(4S)$ decay to two B mesons which both subsequently decay semileptonically enable one to recover the B direction up to a two-fold ambiguity, if all B decay products with the exception of the neutrinos are fully reconstructed.

Signal events require a charm and charmless semileptonic B decay *i.e.* $B_1 \rightarrow D^{(*)}l_1\nu$ (tag side) and $B_2 \rightarrow X_ul_2\nu$ (signal side) ($l = e, \mu$). Choosing for the z axis the $D^{(*)}l$ direction, one can solve for the B direction components, (x_B, y_B, z_B) (see Figure 1),

$$\begin{aligned} x_B^2 &= 1 - \frac{1}{\sin^2 \theta_{12}} (\cos^2 \theta_{B1} + \cos^2 \theta_{B2} - 2 \cos \theta_{B1} \cos \theta_{B2} \cos \theta_{12}) \\ y_B &= \frac{1}{\sin \theta_{12}} (\cos \theta_{B2} - \cos \theta_{B1} \cos \theta_{12}) \\ z_B &= \cos \theta_{B1}. \end{aligned}$$

For pseudo full reconstruction of the $\Upsilon(4S)$, we reconstruct two charged leptons (e^\pm or μ^\pm) and a $D^{(*)}$ meson and assign all other reconstructed particles remaining in the event to the X_u system. To suppress backgrounds, we require $p_{l_2} > 1 \text{ GeV}/c$, $x_B^2 > -0.2$, no charged kaons in X_u , $M_X < 1.5 \text{ GeV}/c^2$, and zero net charge for an event. After MC background subtraction in M_X , for the case X_u consists of at least one π^0 , we find the yield $N_{B \rightarrow X_u l \nu} = 92 \pm 21$ with a reconstruction efficiency of 0.2%, and for X_u without a π^0 , we find the yield $N_{B \rightarrow X_u l \nu} = 89 \pm 19$, with a reconstruction efficiency of 0.05%. The combined M_X distribution is shown in Figure 1.

2.2 Hadronic recoil mass, M_X , and leptonic mass, q^2 , reconstruction with a Simulated Annealing technique

This analyses employs an advanced neutrino reconstruction technique. The requirement of only one reconstructed charged lepton (e or μ) is imposed on the event. The missing 4-momentum in the event is calculated by summing all reconstructed particle 4-momenta and subtracting it from that of the known $\Upsilon(4S)$. A decision tree based on track and neutral cluster quality is used to reduce the number of spurious particles included in the missing momentum calculation. Neutrino reconstruction is further improved by the reconstruction of the other B decay, so called tag. The B_{tag} reconstruction is achieved through a probabilistic and iterative process based on a Simulated Annealing technique¹⁰. The technique minimises a measure, W , which is calculated using *PDFs* of signal and random particle combinations, *i.e.* $W \equiv PDF(random)/(PDF(signal) + PDF(random))$. A signal particle combination corresponds to the case whereby reconstructed particles in the event are correctly assigned to either

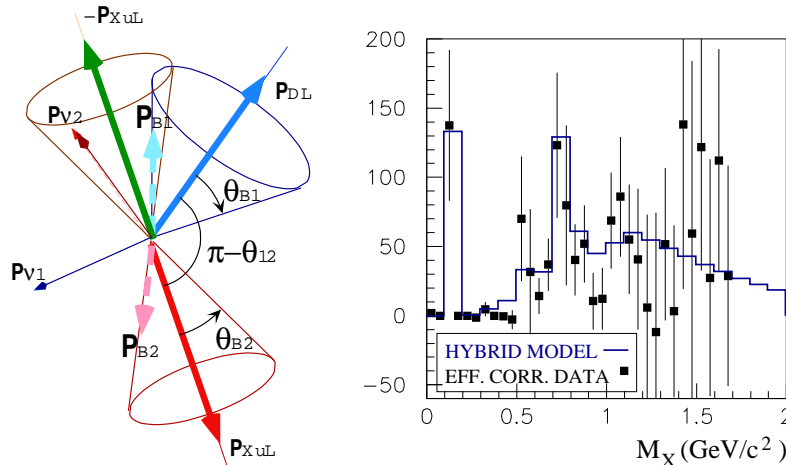


Figure 1: (left) Depiction of two back to back semileptonic B decays, intersection of the two cones identifies the two possible B directions. (right) M_X distribution of efficiency corrected data overlayed with Signal MC histogram (Hybrid Model - $\{\pi, \rho, \eta, \omega\}l\nu$ + inclusive spectrum)

the B_{tag} or X_u . Minimisation of W works to favour correct assignment, and hence correct B_{tag} and X_u reconstruction. The $PDFs$ are functions of the B_{tag} cms momentum, $p_{B_{tag}}^*$, cms energy, $E_{B_{tag}}^*$, number of final state decay products, $N_{B_{tag}}$, cms polar angle, $\cos\theta_{B_{tag}}^*$, the product of B_{tag} and lepton charge, $Q_{B_{tag}} \times Q_l$, and missing mass squared, m_{miss}^2 . A B_{tag} candidate is chosen, if $W < 0.1$, $5.1 < E_B^* < 5.4 \text{ GeV}$, $0.25 < p_B^* < 0.42 \text{ GeV}/c$, $-2 < Q_B \times Q_l < 1$, and $-0.2 < m_{miss}^2 < 0.4 \text{ GeV}^2/c^4$.

The background from non $\Upsilon(4S)$ events is subtracted using 8.8fb^{-1} of OFF resonance data scaled to ON resonance luminosity. The remaining background, estimated using an efficiency corrected MC sample, is subtracted to yield signal q^2 and M_X distributions as shown in Figure 2. In the signal region $M_X < 1.5 \text{ GeV}/c$ and $q^2 > 7 \text{ GeV}/c^2$, we find $N_{B \rightarrow X_u l \nu} = 1270$ with a signal to noise ratio of 0.31.

2.3 $\mathcal{B}(B \rightarrow X_u l \nu)$ and $|V_{ub}|$ measurement

The inclusive rate for charmless semileptonic B decay for the two analyses discussed are shown in Table 1. The uncertainty in the shape and level of the charm semileptonic background estimated from MC samples is quoted as the $b \rightarrow c$ error. The uncertainty in the extrapolation from the partial to the full phase space for $B \rightarrow X_u l \nu$ is quoted as the $b \rightarrow u$ error. The value of $|V_{ub}|$ is calculated according to the PDG 2002 formulation^{4–7}, the uncertainty in its use is quoted as the ‘theory’ error.

	Pseudo full reconstruction of $\Upsilon(4S)$					
	statistical	systematic	$b \rightarrow c$	$b \rightarrow u$	theory	
$\mathcal{B}(B \rightarrow X_u l \nu)(\times 10^{-3})$	2.62	± 0.63	± 0.23	± 0.05	± 0.41	
$ V_{ub} (\times 10^{-3})$	5.00	± 0.60	± 0.23	± 0.05	± 0.39	± 0.36
	q^2 and M_X reconstruction through Simulated Annealing					
	statistical	systematic	$b \rightarrow c$	$b \rightarrow u$	theory	
$\mathcal{B}(B \rightarrow X_u l \nu)(\times 10^{-3})$	1.64	± 0.14	± 0.36	± 0.28	± 0.22	
$ V_{ub} (\times 10^{-3})$	3.96	± 0.17	± 0.44	± 0.34	± 0.26	± 0.29

Table 1: The inclusive branching fraction and $|V_{ub}|$ measurements

3 Measurement of the branching fraction $D_s^+ \rightarrow \phi \pi^+$

We measure the branching fraction, $\mathcal{B}(D_s^+ \rightarrow \phi \pi^+)$ by calculating an efficiency corrected ratio of full to partially reconstructed $B \rightarrow D_s^{*-} D^{*+}$ decays¹¹. In full reconstruction, the D_s is

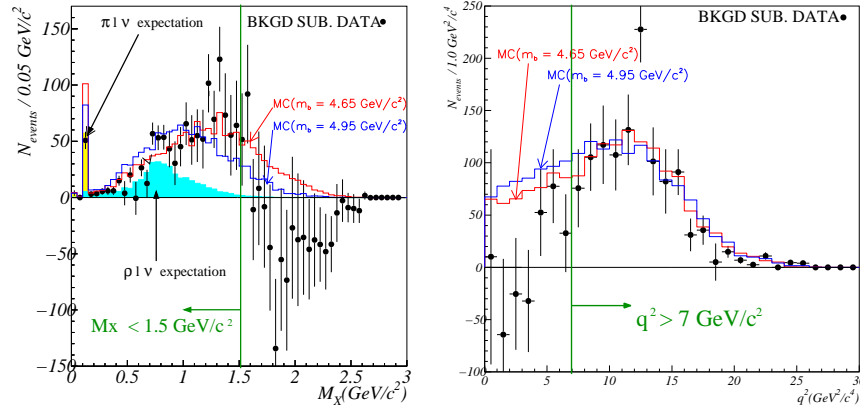


Figure 2: Background subtracted M_X and q^2 distributions overlaid with Signal MC histograms

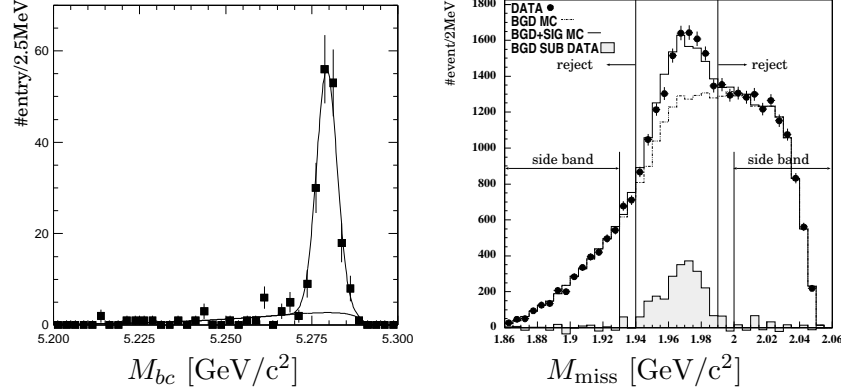


Figure 3: (left) Beam constrained mass for fully reconstructed B candidates and (right) Missing D_s mass distribution for partially reconstructed B candidates

reconstructed through the $\phi\pi$ decay channel, whereas in partial reconstruction the D_s is not reconstructed, rather a soft photon is used to tag the D_s^{*-} decay.

Fully reconstructed B candidates are selected based on the beam constrained mass, $m_{bc} \equiv \sqrt{E_{\text{beam}}^2 - |\vec{p}_{B^0}|^2}$, which must be within 5.27 and 5.29 GeV/c^2 , and energy difference, $\Delta E \equiv E_{\text{beam}} - E_{B^0}$, which must lie between -0.05 and 0.04 GeV (all quantities are calculated in the $\Upsilon(4S)$ rest frame). For events with multiple B candidates, the one with the smallest ΔE is kept. The yield of full reconstructed $B \rightarrow D_s^{*-} D^{*+}$, $N_{\text{full}} = 159.8 \pm 14.1$, is calculated from a fit to the M_{bc} distribution with a Gaussian for the signal component and an ARGUS function¹² for the non $\Upsilon(4S)$ (continuum) background component as shown in Figure 3.

In partial reconstruction, a D^{*-} candidate is fully reconstructed along with a soft photon, γ . The signal is extracted from the missing D_s mass, distribution, M_{miss} , calculated using the assumption $\cos \theta_{B^0\gamma} \simeq -\cos \theta_{B^0 D^{*-}}$, since the soft photon and D^{*-} are almost back to back, and using the nominal B energy in the c.m. frame along with D^{*-} and γ four-momentum. The yield of partially reconstructed $B \rightarrow D_s^{*-} D^{*+}$ decays, $N_{\text{partial}} = 2150.0 \pm 139.5$ is got after a subtraction of MC modeled background normalised to the sideband, see Figure 3. We measure $\mathcal{B}(D_s^+ \rightarrow \phi\pi^+) = (3.72 \pm 0.39_{-0.39}^{+0.47}) \times 10^{-2}$

4 Conclusion

We have discussed new inclusive V_{ub} analyses whose methods are novel and original, and the results of which compare well with previous measurements. Aided by our large data sample we have also reported an improved measurement of the $D_s \rightarrow \phi\pi$ branching fraction.

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